

What is claimed is:

1. A piezoelectric/electrostrictive device comprising:

5 at least an actuator section including a piezoelectric/electrostrictive element secured onto thin plate sections made of metal with an adhesive intervening therebetween, wherein:

an actuator section is constructed by a multilayered member including at least three or more actuator films which are composed of piezoelectric/electrostrictive layer and electrode films.

10 15 2. The piezoelectric/electrostrictive device according to claim 1, wherein a plurality of electrode films, which are included in said multilayered member for constructing said piezoelectric/electrostrictive element, are stacked alternately, and they are connected so that an identical voltage is applied to every other layer.

20 3. The piezoelectric/electrostrictive device according to claim 1, wherein said multilayered member is composed of ten or less said actuator film.

25 4. The piezoelectric/electrostrictive device according to claim 1, wherein said actuator film is formed by means of a thick film printing method.

5      5.    The piezoelectric/electrostrictive device  
according to claim 1, wherein a positional discrepancy in an  
in-plane direction, which possibly occurs on a perpendicular  
projection plane of each of said electrode films disposed as  
every other layer, is not more than 50  $\mu$ m.

6.    The piezoelectric/electrostrictive device  
according to claim 1, wherein said adhesive has a thickness  
of not more than 15  $\mu$ m.

7.    The piezoelectric/electrostrictive device  
according to claim 1, wherein an underlying layer is formed  
on a surface of said piezoelectric/electrostrictive element  
opposed to said thin plate section.

8.    The piezoelectric/electrostrictive device  
according to claim 1, wherein one or more holes or recesses  
are formed at least at a portion of said thin plate section  
at which said piezoelectric/electrostrictive element is  
formed.

9.    The piezoelectric/electrostrictive device  
according to claim 1, wherein at least a portion of a  
surface of said thin plate section, on which said  
piezoelectric/electrostrictive element is formed, is a rough  
surface.

10. A piezoelectric/electrostrictive device comprising a pair of mutually opposing thin plate sections made of metal and a fixation section for supporting said thin plate sections, and including an actuator section with a piezoelectric/electrostrictive element fixed on at least one of said thin plate sections by the aid of an adhesive, wherein:

a stacked type piezoelectric/electrostrictive element is composed of a plurality of piezoelectric/electrostrictive layers and electrode films; and

said electrode films, which contact with upper and lower surfaces of said respective piezoelectric/electrostrictive layers, are alternately led to opposite end surfaces, and end surface electrodes, which electrically connect said respective electrode films alternately led to said opposite end surfaces, are electrically connected to terminals which are provided on a surface of an outermost layer of said piezoelectric/electrostrictive layer and which are arranged while being separated from each other by a predetermined distance respectively.

11. The piezoelectric/electrostrictive device according to claim 10, wherein said stacked type piezoelectric/electrostrictive element has a substantially rectangular parallelepiped-shaped configuration.

12. The piezoelectric/electrostrictive device according to claim 10, wherein said predetermined distance between said terminals is not less than 50  $\mu\text{m}$ .

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13. The piezoelectric/electrostrictive device according to claim 10, wherein at least one of said terminals and one of said end surface electrodes are electrically connected with each other with an electrode film having a film thickness which is thinner than those of said terminal and said end surface electrode.

14. A piezoelectric/electrostrictive device comprising:

a pair of mutually opposing thin plate sections, and a fixation section for supporting said thin plate sections; and

one or more piezoelectric/electrostrictive elements arranged on at least one thin plate section of said pair of thin plate sections, wherein:

a minimum resonance frequency of said device structure, which is obtained when an object member having a size substantially equivalent to that of said fixation section exists between open ends of said pair of thin plate sections, is not less than 20 kHz, and a relative displacement amount between said object member and said fixation section is not less than 0.5  $\mu\text{m}$  at a substantial

applied voltage of 30 V at a frequency which is not more than 1/4 of said resonance frequency.

15. The piezoelectric/electrostrictive device according to claim 14, wherein:

an adhesive intervenes between said piezoelectric/electrostrictive element and said thin plate section; and

said adhesive has a thickness which is not more than 10 % of a thickness of said piezoelectric/electrostrictive element.

16. The piezoelectric/electrostrictive device according to claim 14, wherein:

said one or more piezoelectric/electrostrictive elements are arranged on one thin plate section of said pair of thin plate sections; and

a thickness of said one thin plate section is thicker than a thickness of the other thin plate section.

17. The piezoelectric/electrostrictive device according to claim 14, wherein:

said object member intervenes between said open ends of said pair of thin plate sections, and wherein:

a distance concerning said pair of thin plate sections between a boundary portion with respect to said object member and a boundary portion with respect to said fixation

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22. The piezoelectric/electrostrictive device according to claim 18, wherein said plurality of electrode films, which are included in said multilayered member for constructing said piezoelectric/electrostrictive element, are stacked alternately, and they are connected so that an identical voltage is applied to every other layer.

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23. The piezoelectric/electrostrictive device according to claim 22, wherein said piezoelectric/electrostrictive element is formed such that only a first piezoelectric/electrostrictive layer, or both of a first electrode film and a first piezoelectric/electrostrictive layer of the multilayered member for constructing the piezoelectric/electrostrictive element make contact with said thin plate section.

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24. The piezoelectric/electrostrictive device according to claim 22, wherein one of ends of said electrode layer is formed at a position not including at least said fixation section as viewed in plan view.

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25. The piezoelectric/electrostrictive device according to claim 18, wherein an end of said multilayered member for constructing said piezoelectric/electrostrictive element is formed at a position not including at least said fixation section as viewed in plan view.

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26. The piezoelectric/electrostrictive device according to claim 24, wherein:

said object member intervenes between said open ends of said pair of thin plate sections, and wherein:

(1 -  $L_b/L_a$ ) is not less than 0.4, provided that:

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$L_a$  represents a shortest distance concerning said pair of thin plate sections between a boundary portion with respect to said object member and a boundary portion with respect to said fixation section; and

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$L_b$  represents a shortest distance of distances from said boundary portion between said thin plate section and one of said object member and said fixation section on which said multilayered member for constructing said piezoelectric/electrostrictive element is not formed, to an end of said electrode film.

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27. The piezoelectric/electrostrictive device according to claim 26, wherein (1 -  $L_b/L_a$ ) is 0.5 to 0.8.

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28. The piezoelectric/electrostrictive device according to claim 14, wherein said thin plate sections is composed of metal.

29. The piezoelectric/electrostrictive device according to claim 28, wherein said thin plate sections is composed of a metal plate subjected to a cold rolling



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30. The piezoelectric/electrostrictive device according to claim 18, wherein an adhesive, which has a thickness of not less than 0.1  $\mu\text{m}$  and not more than 30  $\mu\text{m}$ , is allowed to intervene between said thin plate sections and said multilayered member for constructing said piezoelectric/electrostrictive element.

10 31. The piezoelectric/electrostrictive device according to claim 30, wherein said adhesive is composed of organic resin.

15 32. The piezoelectric/electrostrictive device according to claim 30, wherein said adhesive is composed glass, brazing material, or solder.

20 33. The piezoelectric/electrostrictive device according to claim 30, wherein an underlying layer is formed on a surface of said multilayered member opposed to said thin plate section.

25 34. The piezoelectric/electrostrictive device according to claim 30, wherein one or more holes or recesses are formed at least at a portion of said thin plate section at which said multilayered member is formed.

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35. The piezoelectric/electrostrictive device according to claim 30, wherein at least a portion of a surface of said thin plate section, on which said multilayered member is formed, is a rough surface.

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36. The piezoelectric/electrostrictive device according to claim 14, wherein an adhesive, which has a thickness of not less than 0.1  $\mu\text{m}$  and not more than 30  $\mu\text{m}$ , is allowed to intervene between said thin plate section and at least said fixation section.

37. The piezoelectric/electrostrictive device according to claim 36, wherein said adhesive is composed of organic resin.

38. The piezoelectric/electrostrictive device according to claim 36, wherein said adhesive is composed of glass, brazing material, or solder.

39. The piezoelectric/electrostrictive device according to claim 36, wherein a stick-out shape of said adhesive, which protrudes from an opposing portion between said thin plate section and at least said fixation section, has a curvature.

40. The piezoelectric/electrostrictive device according to claim 36, wherein:

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an object member intervenes between open ends of said pair of thin plate sections, and wherein:

at least an angular portion of said fixation section opposed to said object member is chamfered.

41. The piezoelectric/electrostrictive device according to claim 36, wherein:

said thin plate section is manufactured by means of stamping for a metal plate, and wherein:

a burr, which is brought about by said stamping, is directed outwardly.

42. A method for producing a piezoelectric/electrostrictive device comprising:

a pair of mutually opposing thin plate sections, and a fixation section for supporting said thin plate sections; and

one or more piezoelectric/electrostrictive elements arranged on at least one thin plate section of said pair of thin plate sections, said method comprising the steps of:

preparing a plurality of thin plates for forming at least said thin plate sections thereafter, said piezoelectric/electrostrictive element, and a support substrate;

securing said piezoelectric/electrostrictive element to at least one of said thin plates by the aid of a first adhesive;

securing said plurality of thin plates to said support substrate by the aid of a second adhesive to manufacture a master device block including said plurality of thin plates disposed opposingly; and

5       dividing said master device block into a plurality of chips to manufacture individuals of said piezoelectric/electrostrictive devices.

10       43. The method for producing said piezoelectric/electrostrictive device according to claim 42, wherein:

15       when an object member intervenes between open ends of said pair of thin plate sections of said piezoelectric/electrostrictive device to be produced;

      said support substrate is a rectangular annular structure having a portion to be formed into at least said object member thereafter, and a portion to be formed into said fixation section thereafter.

20       44. The method for producing said piezoelectric/electrostrictive device according to claim 42, wherein:

      when an object member does not intervene between open ends of said pair of thin plate sections of said piezoelectric/electrostrictive device to be produced;

25       said support substrate is a rectangular annular structure having a portion for supporting said open ends, and a portion to be formed into said fixation section thereafter.

45. The method for producing said piezoelectric/  
electrostrictive device according to claim 42, wherein said  
first adhesive and/or said second adhesive is organic resin.

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46. The method for producing said piezoelectric/  
electrostrictive device according to claim 42, wherein said  
first adhesive and/or said second adhesive is glass, brazing  
material, or solder.

47. The method for producing said piezoelectric/  
electrostrictive device according to claim 42, wherein said  
thin plates and/or said support substrate is made of metal.

48. The method for producing said piezoelectric/  
electrostrictive device according to claim 42, wherein:

when said step of dividing said master device block  
includes a treatment for cutting said master device block  
along predetermined cutting lines;

said cutting is performed in substantially the same  
direction as a displacement direction of said pair of thin  
plate sections.

49. The method for producing said piezoelectric/  
electrostrictive device according to claim 42, further  
comprising the step of forming an underlying layer on a  
surface of said piezoelectric/electrostrictive element

opposed to said thin plate before securing said piezoelectric/electrostrictive element to said thin plate by the aid of said first adhesive.

5           50. The method for producing said piezoelectric/electrostrictive device according to claim 42, further comprising the step of forming one or more holes or recesses at least at a portion of said thin plate to which said piezoelectric/electrostrictive element is secured.

10           51. The method for producing said piezoelectric/electrostrictive device according to claim 42, further comprising the step of roughen at least a portion of a surface of said thin plate to which said  
15 piezoelectric/electrostrictive element is secured.

20           52. The method for producing said piezoelectric/electrostrictive device according to claim 42, further comprising the step of forming a curvature for a stick-out shape of said second adhesive protruding from an opposing portion between said thin plate and said support substrate.

25           53. The method for producing said piezoelectric/electrostrictive device according to claim 42, further comprising the step of chamfering mutually opposing angular portions of said support substrate of said master device block.

54. The method for producing said piezoelectric/  
electrostrictive device according to claim 42, further  
comprising the step of:

5 manufacturing said thin plate by means of stamping for  
a metal plate, wherein:

when said master device block is produced by combining  
said thin plate with said support substrate, a burr, which  
is brought about on said thin plate due to said stamping, is  
directed outwardly to produce said master device block.

55. A method for producing a piezoelectric/  
electrostrictive device comprising:

a pair of mutually opposing thin plate sections, and a  
fixation section for supporting said thin plate sections;  
and

one or more piezoelectric/electrostrictive elements  
arranged on at least one thin plate section of said pair of  
thin plate sections, said method comprising the steps of:

preparing a plurality of thin plates for forming at  
least said thin plate sections thereafter, said  
piezoelectric/electrostrictive element, and a support  
substrate;

25 securing said plurality of thin plates to said support  
substrate by the aid of a second adhesive;

securing said piezoelectric/electrostrictive element to

at least one of said thin plates by the aid of a first adhesive to manufacture a master device block including said plurality of thin plates disposed opposingly; and

dividing said master device block into a plurality of chips to manufacture individuals of said piezoelectric/electrostrictive devices.

56. The method for producing said piezoelectric/electrostrictive device according to claim 55, wherein:

when an object member intervenes between open ends of said pair of thin plate sections of said piezoelectric/electrostrictive device to be produced;

said support substrate is a rectangular annular structure having a portion to be formed into at least said object member thereafter, and a portion to be formed into said fixation section thereafter.

57. The method for producing said piezoelectric/electrostrictive device according to claim 55, wherein:

when an object member does not intervene between open ends of said pair of thin plate sections of said piezoelectric/electrostrictive device to be produced;

said support substrate is a rectangular annular structure having a portion for supporting said open ends, and a portion to be formed into said fixation section thereafter.



58. The method for producing said piezoelectric/  
electrostrictive device according to claim 55, wherein said  
first adhesive and/or said second adhesive is organic resin.

5 59. The method for producing said piezoelectric/  
electrostrictive device according to claim 55, wherein said  
first adhesive and/or said second adhesive is glass, brazing  
material, or solder.

10 60. The method for producing said piezoelectric/  
electrostrictive device according to claim 55, wherein said  
thin plates and/or said support substrate is made of metal.

15 61. The method for producing said piezoelectric/  
electrostrictive device according to claim 55, wherein:  
when said step of dividing said master device block  
includes a treatment for cutting said master device block  
along predetermined cutting lines;

20 said cutting is performed in substantially the same  
direction as a displacement direction of said pair of thin  
plate sections.

25 62. The method for producing said piezoelectric/  
electrostrictive device according to claim 55, further  
comprising the step of forming an underlying layer on a  
surface of said piezoelectric/electrostrictive element  
opposed to said thin plate before securing said

piezoelectric/electrostrictive element to said thin plate by the aid of said first adhesive.

5 63. The method for producing said piezoelectric/electrostrictive device according to claim 55, further comprising the step of forming one or more holes or recesses at least at a portion of said thin plate to which said piezoelectric/electrostrictive element is secured.

10 64. The method for producing said piezoelectric/electrostrictive device according to claim 55, further comprising the step of roughen at least a portion of a surface of said thin plate to which said piezoelectric/electrostrictive element is secured.

15 65. The method for producing said piezoelectric/electrostrictive device according to claim 55, further comprising the step of forming a curvature for a stick-out shape of said second adhesive protruding from an opposing portion between said thin plate and said support substrate.

20 66. The method for producing said piezoelectric/electrostrictive device according to claim 55, further comprising the step of chamfering mutually opposing angular portions of said support substrate of said master device block.

67. The method for producing said piezoelectric/  
electrostrictive device according to claim 55, further  
comprising the step of:

5 manufacturing said thin plate by means of stamping for  
a metal plate, wherein:

when said master device block is produced by combining  
said thin plate with said support substrate, a burr, which  
is brought about on said thin plate due to said stamping, is  
directed outwardly to produce said master device block.

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